3 SITE

300 GENERAL

Location

The site is located in the town of Rowe, Massachusetts, on the east bank of the Deerfield River at a point approximately three-quarters of a mile south of the Vermont-Massachusetts border. It is adjacent to the Sherman hydroelectric station of the New England Power Company. The location is shown on page 300:2. Details of the topographical features of this area may be found on United States Coast and Geodetic Survey Map, "Massachusetts-Vermont, Rowe Quadrangle".

Access

The site may be reached from the south by a secondary road which runs from Massachusetts Route 2, near the town of Charlemont through the village of Zoar and then via the village of Rowe or, as an alternate, by a road passing the mouth of the Hoosac Tunnel and through the village of Monroe Bridge. From the north, a possible approach leaves Vermont Route 9 at the town of Wilmington and leads via Jacksonville and Readsboro to Monroe Bridge village. The distances by road to the site are 13 miles from Route 2 and 21 miles from Route 9.

The Hoosac Tunnel and Wilmington Railroad connects with a main line of the Boston and Maine Railroad at the eastern portal of the Hoosac Tunnel, about 7.5 miles east of North Adams, Massachusetts. From this point, the Hoosac Tunnel and Wilmington Railroad follows the Deerfield River approximately 12 miles north to the town of Readsboro, Vermont, passing the Yankee plant at the 6.5 mile point.

Population

The following tabulation, based on 1950 census data, shows the population within various distances from the site. The effect on the city of North Adams, Massachusetts is shown. The various zones are indicated on the map on page 300:3.

Distance from Site, Miles	Area, Square Miles	Population		Density - Persons/Sq Mile
		Including North Adams	Excluding North Adams	Excluding North Adams
0-1	3.1		174	55
1-5	75.6		1,862	25
0-5	78.7		2,036	26
5-10	235	26,946	5,379	23
0-10	314	28,982	7,415	24
10-20	946		75,311	80
0-20	1,260	104,293	82,726	66

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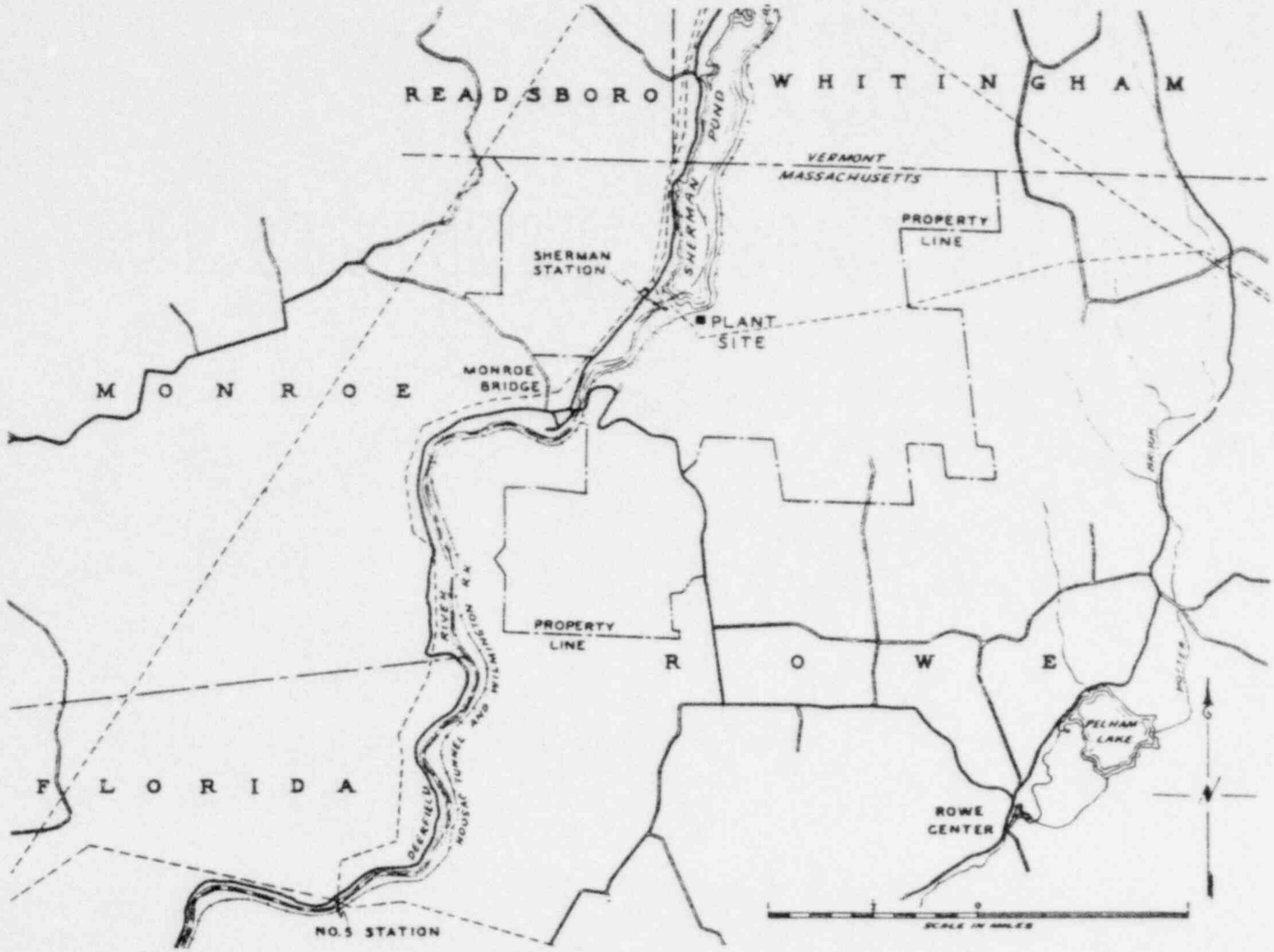
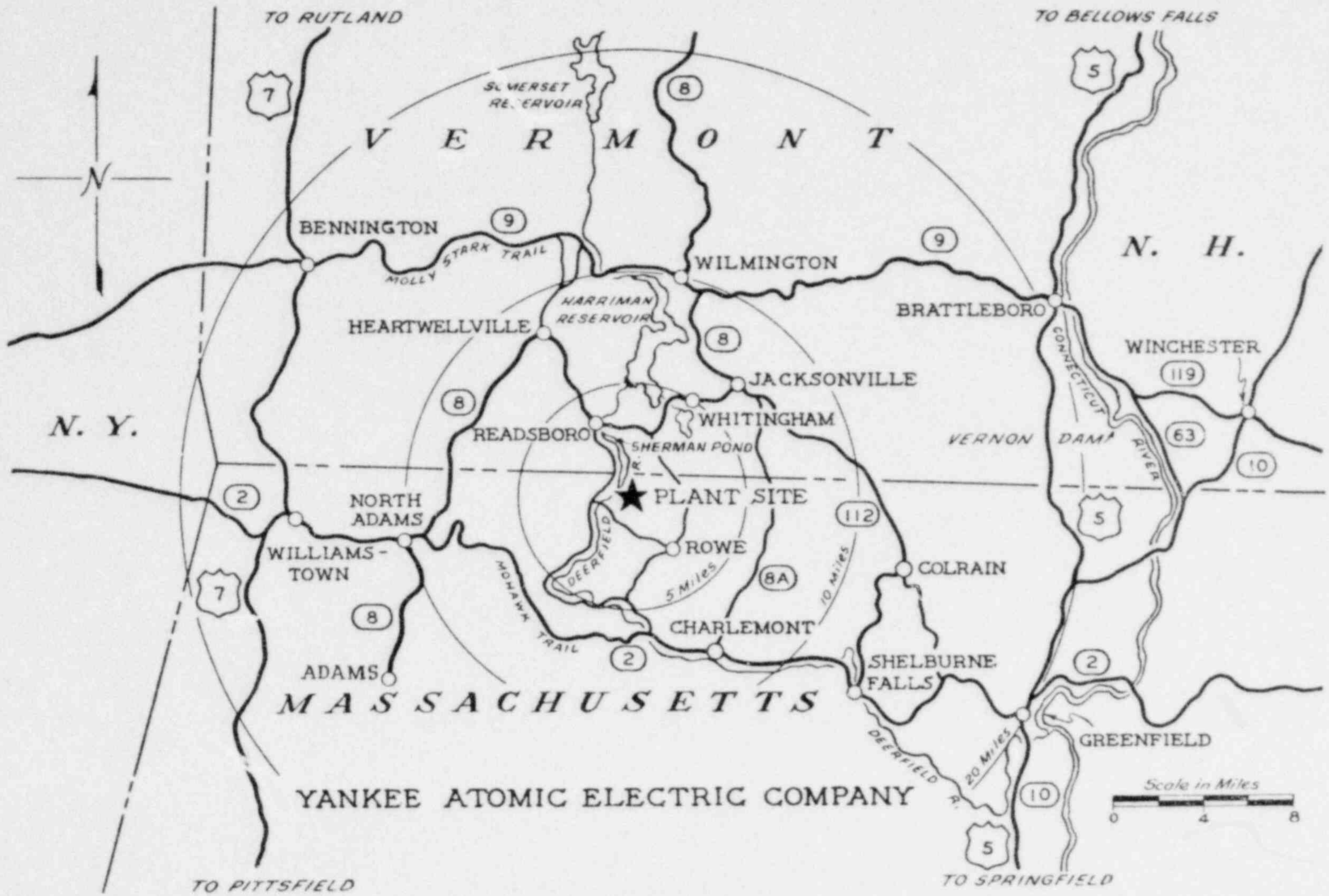


MAP OF PROPERTY OWNED BY
YANKEE ATOMIC ELECTRIC COMPANY
AND
NEW ENGLAND POWER COMPANY

300:2
1/10/60

GENERAL AREA MAP



YANKEE ATOMIC ELECTRIC COMPANY

300:3
9/15/59

The towns within a 20 mile radius which have a population in excess of 2,500, together with their distances and directions from the site, are as follows:

Town	Population	Airline Distance, Miles	Direction from Site
North Adams, Mass.	21,567	9	WSW
Greenfield, Mass.	17,349	19	SE
Bennington, Vt.	12,411	17	NW
Adams, Mass.	12,034	12	SW
Brattleboro, Vt.	11,522	20	NE
Williamstown, Mass.	6,194	13	WSW

Land Use

There are only three industrial developments within 10 miles of the site, excluding North Adams and small sawmills. These are a box company in Wilmington, Vermont, a hardwood products company in Readsboro, Vermont, and a paper company at Monroe Bridge, Massachusetts. There is a knife manufacturing company and a steel products company down river at Shelburne Falls.

Greenfield and North Adams are the only important centers of manufacturing from the point of view of this report; North Adams, because of its relative proximity to the site, and Greenfield, because it is on the Deerfield River.

Closely populated areas are found only in the centers of each town, so that the total land area devoted to housing is small.

All of the remaining land is utilized as forest or cultivated crop land.

Detailed land use figures in individual towns are not available, but the following data from the 1954 Census of Agriculture show the percentage of land devoted to crops in each of the four counties near the site:

County	Total Land Area, Acres	Crop Land	
		Acres	Per Cent
Berkshire, Mass.	602,880	71,000	11.8
Franklin, Mass.	452,480	56,500	12.5
Bennington, Vt.	430,080	36,800	8.6
Windham, Vt.	507,520	43,900	8.7

Public Water Supplies

The main stream of the Deerfield River travels a distance of 41.2 river miles between the Sherman Dam and its confluence with the Connecticut River.

There are no downstream towns which use water pumped directly from the main stream of the river for domestic purposes. In the Mill Village section of Deerfield, one gravel packed well, located within 1,000 ft of the river, feeds into a public water supply which probably serves a part of the town.

In other towns, only the village of Monroe Bridge and the towns of Shelburne Falls and Greenfield have public water supplies. These systems obtain water from springs, wells, or reservoirs on or near tributary streams.

Site Layout

Yankee and its affiliated company, New England Power Company, own approximately 2,000 acres located on both sides of the Deerfield River, as shown on page 300:2. All of this land with the exception of the roads indicated and a group of five houses in the Monroe Bridge area is in the form of forest and unused farm land. The location of the plant is at the easterly end of the Sherman Dam. This location was selected because of level nature of land, adequate foundation conditions, nearness to the Sherman Pond for cooling water supplies, and convenient access by both highway and railroad.'

In addition, proximity to the high tension switching substation at the Harriman hydroelectric station of New England Power Company, in Readsboro, Vermont, facilitates the delivery of power to the interconnected transmission systems of the New England utilities which propose to purchase the output of the Yankee plant.

"A private road on land of the Yankee Atomic Electric Company extends to the southwest a distance of approximately one-half mile where it connects to a secondary highway between the villages of Monroe Bridge and Rowe. This is the regular means of access to the plant. However, the highway between the villages has grades up to 26 per cent and may be impassable at times in winter."

"The highway from Monroe Bridge village which follows along the west side of the Deerfield River, across from the power plant and approximately 1,000 ft distant at its nearest point, is a black-top town road. Emergency access between this highway and the power plant is possible across the top of Sherman Dam, belonging to and subject to complete control by the New England Power Company. The New England Power Company also owns almost all the land in the vicinity on both sides of the state road, thus making it unlikely that outside parties will construct homes or other permanent installations in this area."

"Except for the private road and the way across the dam, all access to the plant site by motor vehicles is blocked by the river and by a range of high hills."

301 METEOROLOGY

James M. Austin, Associate Professor of Meteorology, Massachusetts Institute of Technology, has evaluated the meteorology of the Yankee site and has advised in the selection of instruments and the collection of data. His report of this work is as follows:

POLLUTION CLIMATOLOGY OF THE DEERFIELD RIVER SITE

By

James M. Austin

Topography

The most important factor to consider in this pollution survey is the unusual topography in the vicinity of the site. The Deerfield River meanders through the hilly regions of western Massachusetts and southern Vermont. At the site the elevation of the land is approximately 1,150 ft above sea level. Within a horizontal distance of 1 mile, the hills on both sides of the valley rise to an elevation of 2,000 ft, approximately. This steep-sloped character of the river valley exists to Charlemont, eight airline miles southeast of the site, and beyond Wilmington, Vt., to the branches of the river 12 miles north of the site. Between these two towns the valley takes a very erratic course with a general decrease in elevation to the south. The valley is densely wooded on both sides.

To analyze the dispersal of radioactive products from a site in such a deep river valley, it is necessary to distinguish between two contrasting meteorological regimes:

(1) Under unstable conditions, air within the valley is continually mixed with the free-air flow above the ridges and, consequently, the ultimate dispersion is in a direction determined by the wind direction at the hill-top level. In the immediate vicinity of the site, the direction is locally influenced by the topography with a tendency for up and down valley winds.

(2) With a stable stratification, the valley is isolated from the general air flow over the area except when the flow is down the valley, that is, from a north or northeast direction. Hence, under stable conditions, expected dispersion from the site must be calculated from wind observations taken within the valley.

The subsequent analysis emphasizes the characteristics of the wind field with each regime together with the frequency of occurrence of the regime.

Availability of Meteorological Data

The general air motion over the area is deduced from the 2,000 ft pilot balloon observations taken at Albany, New York, located approximately 40 miles to the west of the site. A broad stability classification is based upon the temperature difference between the 5,000 ft temperature at Albany and the surface temperature at Pittsfield. Since the upper-air temperature observations at Albany were discontinued in November 1951, it was not possible to utilize surface temperature data taken after 1955 at the Hoosac Tunnel station within the valley. The use of the Pittsfield data is justified by the comparison presented in Table on page 301:8. The Albany data are thus utilized to describe the wind regime pertinent for the analysis of pollution with an unstable stratification of the atmosphere.

The air circulation within the valley has been determined from three sources of data:

(1) A Bendix-Friez Aerovane was maintained at the southeasterly end of Sherman Dam from 1957 to 1959. The anemometer is mounted on top of a 30 ft utility pole; this location in the middle of the valley is approximately 500 ft northwest of the reactor.

(2) Because of the reported high frequency of light to calm winds, sensitive Beckman-Whitley, Type F, anemometers were installed in March 1959. One anemometer is located on the top of a 50 ft pole 150 ft from the above-mentioned Aerovane. The second instrument is 20 ft above the top of a knoll on the east slope, approximately 1,800 ft from the reactor site, and at an elevation of 460 ft above the reactor. The calibration of these instruments, including the 1/2 mph starting speed, was verified and checks were conducted to ensure that they maintained their sensitive characteristics. At the same two locations, temperature observations were obtained from Foxboro Recording Thermometers and these data were utilized to determine the stability classification of tables on pages 301:12 and 13.

(3) From April to July 1959, temperature and wind profiles were measured at the reactor site and in different parts of the valley through the use of a kytoon, a Hastings airmeter, and a thermistor. A number of low-ascent balloons also provided information on the air motion within the valley.

Wind Regime Under Unstable Conditions

The analysis of the 2,000 ft pilot balloon observations from Albany for the years 1945, 1946, and 1947, is presented in Table on pages 301:9, 10. When inclement weather prevented a 2,000 ft observation, either the 1,000 ft report was utilized and the speed increased by 10%

or the surface wind at Pittsfield was used with a 60% increase in speed. Only 10% of the 2,000 ft wind velocities were estimated indirectly. The stability classes are defined as follows:

$T_{sfc} - T_{850}$	Class
$-\infty$ to 10 F	Stable
+11 F to 20 F	Moderate lapse
+20 F to ∞	Unstable

where T_{850} refers to the 850 mb, or 5,000 ft temperature and T_{sfc} is the surface temperature at 1:30 A.M. and 1:30 P.M. for night and day, respectively.

From Table on pages 301:9, 10, it is apparent that mixing between the valley air and the free atmosphere can be expected to occur 30 (unstable) to 75 (moderate lapse and unstable) per cent of the time during the daytime. Under these conditions radioactive material would be carried out of the valley by winds with a predominant westerly component.

At night, however, mixing with air outside the valley cannot be expected to occur more than 20% of the time. Particularly during the summer half-year, the valley at nighttime is essentially isolated from the free-air flow.

Wind Regime Under Stable Conditions

The above statistics emphasize the importance of considering the air circulation within the valley, especially at night. The wind data summarized in Table on page 301:11 indicate that wind speeds less than 3 mph prevail on 78% of nights and 31% of the days. There is a pronounced tendency for the wind to blow up or down the valley.

The records from the sensitive Beckman-Whitley anemometers have been summarized in Table on pages 301:12, 13. They show that for the spring and early summer of 1959 the frequency of occurrence of light winds (less than 3 mph) was less than that indicated in Table on page 301:11. It is considered that this difference arises, at least in part, from the different characteristics of the two anemometers at low wind speeds.

The most striking feature of the anemometer records was the high degree of wind fluctuation on clear nights with mean speeds in the 1.0-4.0 mph range. The direction fluctuation over a 10 min period consistently averaged between 45 and 90+ deg. Hence 12 deg is a conservative estimate of the standard deviation of the wind direction on clear nights with light winds and a pronounced temperature inversion. This unusually high degree of eddying motion is attributed to the drainage currents down the tortuous slopes of the steep valley and the influence of the many promortories in breaking up the characteristic laminar type flow at night. A particularly light-wind weather situation was chosen for a smoke test to verify the representativeness of the anemometer records. A series of smoke trails were released on the night of July 17-18, 1959. On each occasion the smoke dispersed rapidly in the horizontal and in the vertical so that within 2,500 ft of the site the dispersion was restricted by the narrowness of the valley.

The kytoon observations were undertaken at a number of different localities in the vicinity of the site and toward Monroe Bridge. On a clear night the wind is predominately down-valley, i.e. N to ENE, and some characteristic observations are given in Table on page 301:14. With a generally prevailing wind from a southerly direction the wind in the valley remains south provided that the flow is sufficiently strong. The kytoon displayed the night-time eddying motion referred to in the previous paragraph.

In summary, the data indicate that light winds predominate within the valley at nighttime. However, despite the temperature inversion, the air motion is turbulent thereby providing a relatively high degree of dispersion of any effluent.

Diffusion Estimates

The foregoing summary of meteorological conditions provides the basic wind information required to calculate the concentration of radioactive material at varying distances from the reactor. It is proposed to estimate these concentrations for two sources; namely, a ground level release as would occur with an accident and an elevated source associated with the continuous operation of the reactor. Further, since diffusion theory and field experiment have provided alternative methods for computing concentrations, some of these alternatives are included to show the expected range of calculated values. Finally, particular attention is devoted to the unique circulation in the valley insofar as the formulae apply to diffusion over relatively flat terrain.

Subsequent concentration estimates will be based upon the following equations for diffusion from a continuous point source:

$$\chi_{(x,y,z)} = \frac{2Q}{\pi C_y C_z u x^{2-n}} \exp\left[-x^{n-2}\left(\frac{y^2}{C_y^2} + \frac{z^2}{C_z^2}\right)\right] \quad (1)$$

Where χ_{xyz} is the downwind concentration from a source of strength Q, u is the mean wind speed in the x-direction, y is the coordinate in the crosswind direction, z is the vertical coordinate, and n, C_y and C_z are diffusion parameters defined by Sutton (1).

The maximum concentration at $y = z = 0$ is

$$\chi_{(y=z=0)} = \frac{2Q}{\pi C_y C_z u x^{2-n}} \quad (2)$$

The maximum concentration at ground level from a source of elevation h is

$$\chi_{max} = \frac{2Q}{\pi h^2 u e}\left(\frac{C_z}{C_y}\right) \qquad (3)$$

An alternative set of formulae have been provided by Cramer (2):

$$\chi_{(x,y,z)} = \frac{Q}{\pi u x^b \sigma_A \sigma_E} \exp\left[-\frac{1}{2}\left(\frac{y^2}{\sigma_A^2 x^{2q}} + \frac{z^2}{\sigma_E^2 x^{2p}}\right)\right] \qquad (4)$$

$$\chi_{(y=z=0)} = \frac{Q}{\pi u x \; \sigma_A \sigma_E} \qquad (5)$$

$$\chi_{max} = \frac{Q\left(\frac{b}{p}\right)^{\frac{b}{2p}} \left(\sigma_E\right)^{\frac{b}{p}-1}}{\pi u h^{b/p} \; \sigma_A} \exp\left[-\frac{b}{2p}\right] \qquad (6)$$

Where σ_A and σ_E are the standard deviations of the horizontal and vertical wind direction fluctuations, expressed in radians, p and q are power exponents for a nonrectilinear spread of a plume and $b = p+q$. The suggested values for these constants are presented in Table on page 301: 15 . In applying the above-mentioned formula to flow within the valley, it must be recognized that the valley walls ultimately restrict the lateral diffusion.

The foregoing formulae may be utilized to calculate downwind concentrations from a point source. For the estimate of diffusion downwind from a stack, it is necessary first to consider the mixing which takes place directly above the stack through entrainment into the rising jet of effluent. The height that the plume rises (Δh) can be computed from the following equations:

$$\Delta h = \frac{3.8 V_s d}{u} \qquad \text{Bosanquet (2)} \qquad (7)$$

$$\Delta h = \frac{1.5 V_s d}{u} \qquad \text{Oak Ridge (5)} \qquad (8)$$

where V_s and u are the exit and ambient air speeds, respectively, and d is the stack diameter. Further, Bosanquet (3) calculates that the air entrained per second into the rising jet is equal to $\pi V_s d \, \Delta h \tan 12^\circ/2$ thus giving a dilution factor of $1.6 V_s/u$. There is uncertainty as to the value of Δh, however, from conservation of momentum considerations, it is apparent that the dilution of stack effluent through entrainment immediately above the stack must be of the order of V_s/u.

The point-source formulae [Equations (1)-(6)] may be used to compute concentrations downwind from the volume source above the stack by considering a virtual source, of strength Q, x feet upwind for the stack at an elevation of $h + \Delta h/2$. For a consideration of maximum ground-level concentrations, it must be noted that the jet effect for the stack is significant only insofar as the stack height is raised by an increment Δh. Hence, in equations (3) and (6), h should be replaced by $h + \Delta h$.

Conclusions

The significant conclusions of the meteorological study are the following:

(1) With the moderate lapse and unstable atmospheric conditions, which exist 50% of the time, effluent from the reactor will be diffused in the vertical and transported out of the valley at an elevation far above ground level.

(2) 50% of the time, principally at night, effluent will be restricted to the valley with a predominant light air motion from the north to the south. However, the air flow is unusually turbulent.

(3) The change from nighttime flow to lapse and unstable daytime conditions prevents a long period build up on contamination within the valley. Other sections of the report present calculated concentrations based upon the parameters in Table on page 301:15.

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(1) O. G. Sutton: Micrometeorology, McGraw-Hill, 1953, New York.

(2) H. E. Cramer: Engineering Estimates of Atmospheric Dispersal Capacity. Am. Ind. Hyg. Assoc. J., 20, 183-189.

(3) Bosanquet, Carey and Halten: Dust Deposition from Chimney Stacks. Proc. Inst. Mech. Eng., 162, 1950, No. 3, p. 355.

(4) C. H. Bosanquet: The Rise of a Hot Waste Gas Plume, Paper to the Institute of Fuel, 13 February, 1957.

(5) A Meteorological Survey of the Oak Ridge Area, November 1953, Rpt. -ORO-99, p. 557.

Comparison of Hoosac Tunnel and Pittsfield Temperatures
(Fahrenheit degrees)

	Hoosac Tunnel	Pittsfield
Average Maximum Temperature		
3 Januarys	30.9	30.3
3 Julys	82.5	79.3
Average Minimum Temperature		
3 Januarys	12.2	13.7
3 Julys	55.4	55.9

Percentage frequency of occurrence of nighttime winds, above the valley, in various directions grouped according to stability and season. The numbers in parantheses are the average speeds in mph (nautical). Winter refers to the months of October to March, inclusive.

Direction in Degrees	Winter			Summer		
	Stable	Mod. Lapse	Totals	Stable	Mod. Lapse	Totals
350,360,010	3.8	0.9(16.4)	4.7	4.1	0.9(12.0)	5.0
020,030,040	3.4	0.4(38.0)	3.8	6.6	0.9(19.2)	7.5
050,060,070	3.3	-	3.3	2.7	0.2(10.0)	2.9
080,090,100	1.3	-	1.3	1.3	0.5(12.3)	1.8
110,120,130	1.3	-	1.3	1.7	-	1.7
140,150,160	4.1	0.5(26.0)	4.6	5.0	-	5.0
170,180,190	8.2	0.9(32.4)	9.1	15.8	1.5(27.8)	17.3
200,210,220	7.3	0.5(19.7)	7.8	11.2	0.7(26.0)	11.9
230,240,250	8.0	1.5(27.3)	9.5	6.9	0.2(20.0)	7.1
260,270,280	9.4	5.9(28.7)	15.3	9.3	1.8(22.1)	11.1
290,300,310	15.1	12.3(27.3)	27.4	12.9	4.3(31.4)	17.2
320,330,340	9.3	2.8(24.3)	12.1	9.3	2.4(21.4)	11.7
Totals	74.5%	25.7%	100.0%	86.6%	13.4%	100.0%

Percentage frequency of occurrence of daytime winds, above the valley, in various directions grouped according to stability and season. The numbers in parantheses are the average speeds in mph (nautical). Winter refers to the months of October to March, inclusive.

Direction in Degrees	Winter			
	Stable	Mod. Lapse	Unstable	Totals
350,360,010	2.7	1.6(12.2)	1.6(9.1)	5.9
020,030,040	1.4	1.1(16.7)	0.5(9.7)	3.0
050,060,070	3.1	0.5(3.0)	0.2(5.0)	3.8
080,090,100	0.8	0.2(5.0)	-	1.0
110,120,130	0.6	0.4(13.5)	0.4(4.5)	1.4
140,150,160	2.5	1.1(20.5)	-	3.6
170,180,190	5.7	4.0(17.6)	0.4(6.5)	10.1
200,210,220	3.5	4.3(16.7)	0.9(8.8)	8.7
230,240,250	3.6	4.4(15.4)	2.2(14.5)	10.2
260,270,280	1.1	10.3(19.7)	3.1(17.2)	14.5
290,300,310	4.8	17.1(24.1)	3.3(18.0)	25.2
320,330,340	3.8	5.9(14.2)	2.7(14.9)	12.4
Totals	33.7%	50.8%	15.5%	100.0%

Direction in Degrees	Summer			
	Stable	Mod. Lapse	Unstable	Totals
350,360,010	-	2.2(12.7)	4.2(8.2)	6.4
020,030,040	0.5	2.6(11.4)	2.0(11.5)	5.1
050,060,070	1.1	0.9(10.8)	0.9(6.2)	2.9
080,090,100	0.9	0.9(7.2)	0.4(5.5)	2.2
110,120,130	0.6	0.9(9.8)	0.7(5.8)	2.2
140,150,160	3.5	3.3(12.6)	1.5(8.5)	8.3
170,180,190	2.4	10.1(16.1)	4.2(10.6)	16.7
200,210,220	0.7	4.6(17.7)	5.5(12.0)	10.8
230,240,250	0.4	3.5(16.2)	5.2(11.0)	9.1
260,270,280	0.2	4.1(19.7)	7.0(11.5)	11.3
290,300,310	0.9	6.6(17.6)	9.6(13.4)	17.1
320,330,340	0.2	2.6(15.4)	5.0(11.3)	7.8
Totals	11.4%	42.3%	46.3%	100.0%

Wind speeds at Sherman Dam for the year of 1958. All numbers indicate relative frequencies in percentages.

Speed in mph	≤2	3-5	6-10	≥11
Percentage (Day)	31	18	19	12
(Night)	78	16	14	12
(Total)	54	17	17	12

Percentage frequency of occurrence of winds, at Sherman Dam, in various directions grouped according to stability and speed. Tabulation based upon observations taken from 3/20/59 to 6/30/59, speed in miles per hour and directions in tens of degrees.

	Unstable				Mod. Lapse				Inversion				
Direction / Speed →	0-2	2 1/2-5	6-10	≥11	0-2	2 1/2-5	6-10	≥11	0-2	2 1/2-5	6-10	≥11	Totals
36, 01	0.1	0.6	1.1	0.7	0.3	0.7	1.4	0.5	0.3	0.4	0.4	0.2	6.7
02, 03	0.2	1.1	1.0	1.0	0.1	0.6	1.2	1.4	0.5	1.3	0.5	0.3	9.2
04, 05	0.1	0.8	0.8	0.1	0.1	1.1	0.5	0.2	1.9	3.6	0.3	+	9.7
06, 07	0.3	0.8	0.4	+	0.1	0.9	0.1	0.0	2.6	3.3	0.1	0.0	8.8
08, 09	0.1	0.7	0.4	+	0.2	0.5	0.1	0.2	1.8	1.6	0.1	0.0	5.8
10, 11	0.1	0.4	0.1	0.0	0.1	0.5	+	0.0	1.0	1.3	+	0.0	3.8
12, 13	+	0.2	0.2	0.0	0.2	0.4	0.1	0.0	0.6	0.5	+	0.0	2.2
14, 15	0.0	0.5	0.3	+	0.1	0.1	0.1	0.0	0.5	0.4	0.0	0.0	2.1
16, 17	+	0.9	0.4	0.1	0.6	0.6	0.2	0.0	0.5	0.1	0.0	0.0	3.4
18, 19	0.1	1.0	1.4	0.4	0.4	0.9	0.2	0.0	0.9	0.5	0.1	0.1	5.9
20, 21	0.2	1.7	2.2	0.2	0.5	1.1	1.0	0.3	0.6	0.6	0.4	0.1	8.7
22, 23	0.2	1.6	3.1	1.1	0.4	1.1	2.1	0.9	0.5	0.4	0.3	0.1	11.6
24, 25	+	0.9	1.4	0.9	0.1	0.6	0.7	0.5	0.3	0.4	0.2	0.0	6.1
26, 27	+	0.6	0.7	0.3	0.1	0.2	0.1	0.4	0.2	0.3	+	+	3.2
28, 29	+	0.2	0.6	0.9	0.1	0.1	0.4	0.4	0.2	0.3	+	0.1	3.3
30, 31	0.0	+	0.6	0.4	0.1	0.1	0.4	0.4	0.3	0.4	+	0.2	3.2
32, 33	0.1	0.2	0.5	0.3	+	0.2	0.2	0.4	0.2	0.3	+	0.0	2.5
34, 35	0.1	0.3	0.9	0.6	0.1	0.3	0.7	0.2	0.1	0.2	0.2	0.1	3.9
Totals	1.9	12.7	16.0	7.3	3.7	10.1	9.6	5.8	13.0	15.8	2.8	1.3	100.0

Percentage frequency of occurrence of winds, at hill-top site, in various directions grouped according to stability and speed. Tabulation based upon observations taken from 3/20/59 to 6/30/59, speeds in miles per hour and directions in tens of degrees.

	Unstable				Mod. Lapse				Inversion				
Direction / Speed ⟶	0-2	2 1/2-5	6-10	≥11	0-2	2 1/2-5	6-10	≥11	0-2	2 1/2-5	6-10	≥11	Totals
36, 01	0.1	0.1	0.4	0.6	0.1	0.3	0.9	0.6	0.3	0.5	0.3	0.0	3.9
02, 03	0.0	0.4	0.4	0.5	0.1	1.3	1.2	0.7	0.3	1.2	0.6	0.1	6.5
04, 05	0.0	0.8	0.8	0.3	0.2	1.4	0.6	0.2	0.3	3.3	0.6	0.0	8.2
06, 07	0.1	0.5	0.3	0.0	0.3	1.1	0.3	0.0	0.8	4.1	0.5	0.0	7.8
08, 09	0.1	0.9	0.4	0.2	0.1	0.8	0.3	0.1	0.8	2.9	0.4	0.0	6.8
10, 11	0.0	0.3	0.1	0.0	0.2	0.1	0.0	0.0	0.2	0.4	0.1	0.0	1.2
12, 13	0.0	0.3	0.2	0.0	0.1	0.1	0.0	0.0	0.3	0.3	0.1	0.0	1.3
14, 15	0.0	0.5	0.3	0.0	0.1	0.3	0.1	0.0	0.2	0.3	0.1	0.0	1.7
16, 17	0.0	0.8	0.8	0.6	0.1	0.4	0.2	0.1	0.2	0.4	0.2	0.0	3.6
18, 19	0.3	1.1	1.6	0.9	0.1	0.5	0.5	0.5	0.1	0.8	0.3	0.1	6.7
20, 21	0.1	0.9	1.0	0.7	0.2	1.1	0.8	0.4	0.3	1.1	0.4	0.0	6.6
22, 23	0.1	0.9	0.8	0.7	0.2	0.7	0.7	0.4	0.4	1.2	0.5	0.2	6.4
24, 25	0.1	0.5	1.3	0.7	0.0	0.5	1.3	0.3	0.1	1.2	0.4	0.1	6.3
26, 27	0.1	0.4	1.3	0.7	0.0	0.2	1.0	0.3	0.2	0.9	0.7	0.3	5.9
28, 29	0.1	0.7	1.6	2.0	0.0	0.8	1.3	1.3	0.0	1.1	1.0	0.6	10.2
30, 31	0.1	0.4	1.2	1.7	0.1	0.3	1.1	0.4	0.3	0.4	0.5	0.6	6.8
32, 33	0.1	0.3	1.6	1.2	0.1	0.3	0.8	0.7	0.1	0.7	0.1	0.3	5.8
34, 35	0.0	0.2	0.8	0.9	0.0	0.3	0.8	0.3	0.1	0.7	0.3	0.2	4.2
Totals	0.9	9.5	14.6	11.3	1.5	10.0	11.5	6.0	4.5	21.2	6.5	2.2	100.0

Examples of kytoon observations taken at Sherman Dam. Temperatures are in fahrenheit degrees and wind speeds in mph. Height of the observing site is 1,120 ft.

Date, Time	April 17, 9:15 P.M.		May 6, 5:20 A.M.		June 5, 11:30 P.M.	
Elevation Above Ground, Ft	Temp.	Wind	Temp.	Wind	Temp.	Wind
20	42	NE 3.2	39	E 1.5	61	ESE 1.3
50	45	NNE 3.6	40	NE 1.5	61	SE 0.8
100	45	NNE 4.6	40	N 2.2	61	NE 1.0
150	47	NNE 4.4	40	N 3.3	61	N 1.5
200	46	N 2.7	40	N 4.5	61	N 3.1
250	47	NNE 2.5	40	N 3.3	61	N 4.6
300	46	NNE 4.5	40	N 1.8	61	N 3.1
350	Missing		40	N 5.8	61	N 4.6
400	49	NNE 6.8	41	N 8.2	61	N 3.1
450	49	NNE 7.0	41	N 8.2	61	NNE 3.4
500	49	NNE 6.5	42	N 7.7	61	Missing

Values of Diffusion Parameters

M/sec	η	C_y	C_z	σ_A	σ_E	p	q	b
	Inversion and moderate lapse (70% of the total time)							
4	0.25	0.25	0.20	0.20	0.09	0.9	0.9	1.8
	Unstable flow (30% of total time, principally at day)							
4	0.15	0.3	0.3	0.44	0.17	0.9	1.3	2.2

302 HYDROLOGY

The plant is adjacent to the Deerfield River, alongside the pond formed by Sherman Dam. Surface and subsurface drainage is from the high lands east and south of the site toward the river. The glacial tills of the site contain considerable fine sand with which is blended silt and clay in sufficient amount to make the soil for the most part fairly impermeable to water. The boring and seismic survey plan is shown on page 303:2.

The Deerfield River rises in Sunderland, Vermont, follows a winding course in a southerly direction 30 miles to the Massachusetts-Vermont state line, then continues south about seven miles into Massachusetts where it turns to a wandering but general easterly course for about 36 miles through Shelburne, Deerfield, and Greenfield to its confluence with the Connecticut River. The drainage area above the Sherman Dam is approximately 236 square miles.

Along the Deerfield River are eight hydroelectric plants and two large storage reservoirs, as follows:

Hydroelectric Generating Stations

Station	Ownership	Nominal Plant Capacity, Kw	Elevations* Full Pond	Elevations* Normal Tailwater	Dam Location Miles from Mouth of River
Searsburg	N.E. Power	4,800	1,650	1,416	60.0
Harriman	N.E. Power	45,000	1,392	1,000	47.2
Sherman	N.E. Power	6,500	1,002	921	41.2
No. 5	N.E. Power	15,000	922	676	40.6
No. 4	N.E. Power	6,000	368	299	18.8
No. 3	N.E. Power	6,000	297	229	16.0
Gardner Falls	West. Mass.	3,700	229	189	14.9
No. 2	N.E. Power	7,000	189	123.5	12.9

Storage Reservoirs

	Drainage Area, Sq Miles Gross	Drainage Area, Sq Miles Net	Reservoir Contents Acre-Ft	Reservoir Contents Billion Cu Ft
Somerset	30.0	30.0	57,345	2.498
Harriman	184.0	154.0	116,075	5.056

The United States Government operates a river gage station one mile downstream from Charlemont, Massachusetts. Detailed public records at this point are available from 1913 to date and show the effect of storage reservoir operation.

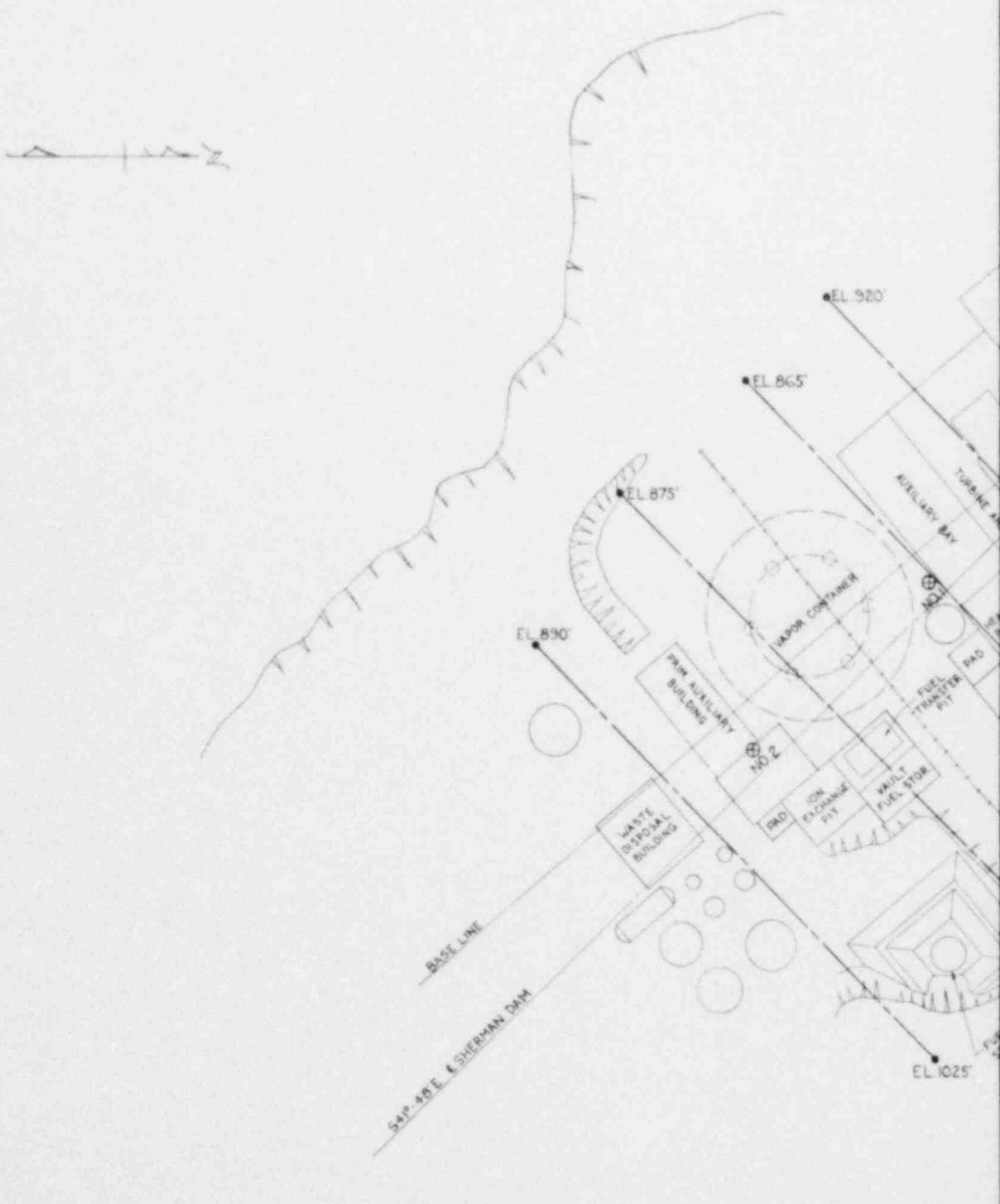
*All elevations on local datum: 0 - 105.66 ft above MSL

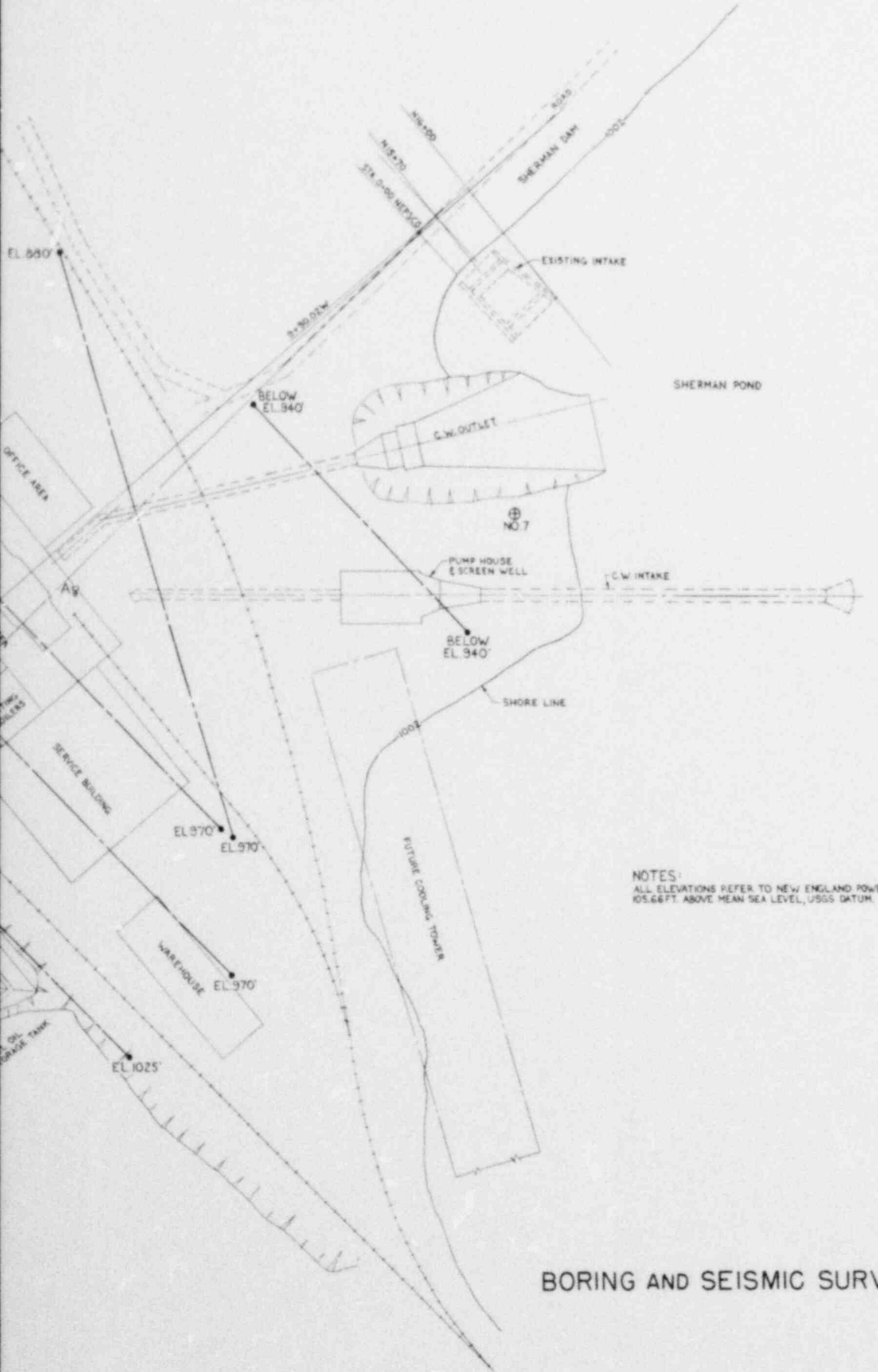
303 GEOLOGY

The site lies in a small valley entering the Deerfield River Valley from the southeast approximately opposite the east end of Sherman Dam. This dam was constructed as a hydroelectric project by the New England Power Company in 1926 and has a maximum height of approximately 90 ft. Except for the Deerfield River Valley the site is surrounded by the Berkshire Mountains, which rise to heights of about 1,000 ft above the site to either side and immediately behind it. This area was overridden by continental ice during Wisconsin glaciation, at which time continental ice reached the central portion of Long Island. It is probable that the surface of the ice sheet at the site was at least 3,000 ft above sea level. The ice sheet almost totally removed all residual soils and the present soil mantle found in this vicinity is predominantly glacial till and drift.

The surface of the bedrock at the site is extremely irregular, solid ledge outcropping in a small hill along the northeast side and again in a large hill to the southeast. Consequently, one of the concerns of the initial site investigation was to establish bedrock elevations within the area as a guide to design in order to keep rock excavation to a minimum. Three borings, Nos. 1, 2, and 7 were made at the locations shown on page 303:2. A small gravel pit afforded an examination of the upper soil. A seismic survey was made to check depths to bedrock. The seismic survey was run using the refraction technique, the depth of bedrock being determined at the end of each seismic survey line. The elevation at each point where it was determined is shown on page 303:2. These elevations indicate that the surface of the rock generally slopes toward the Deerfield River.

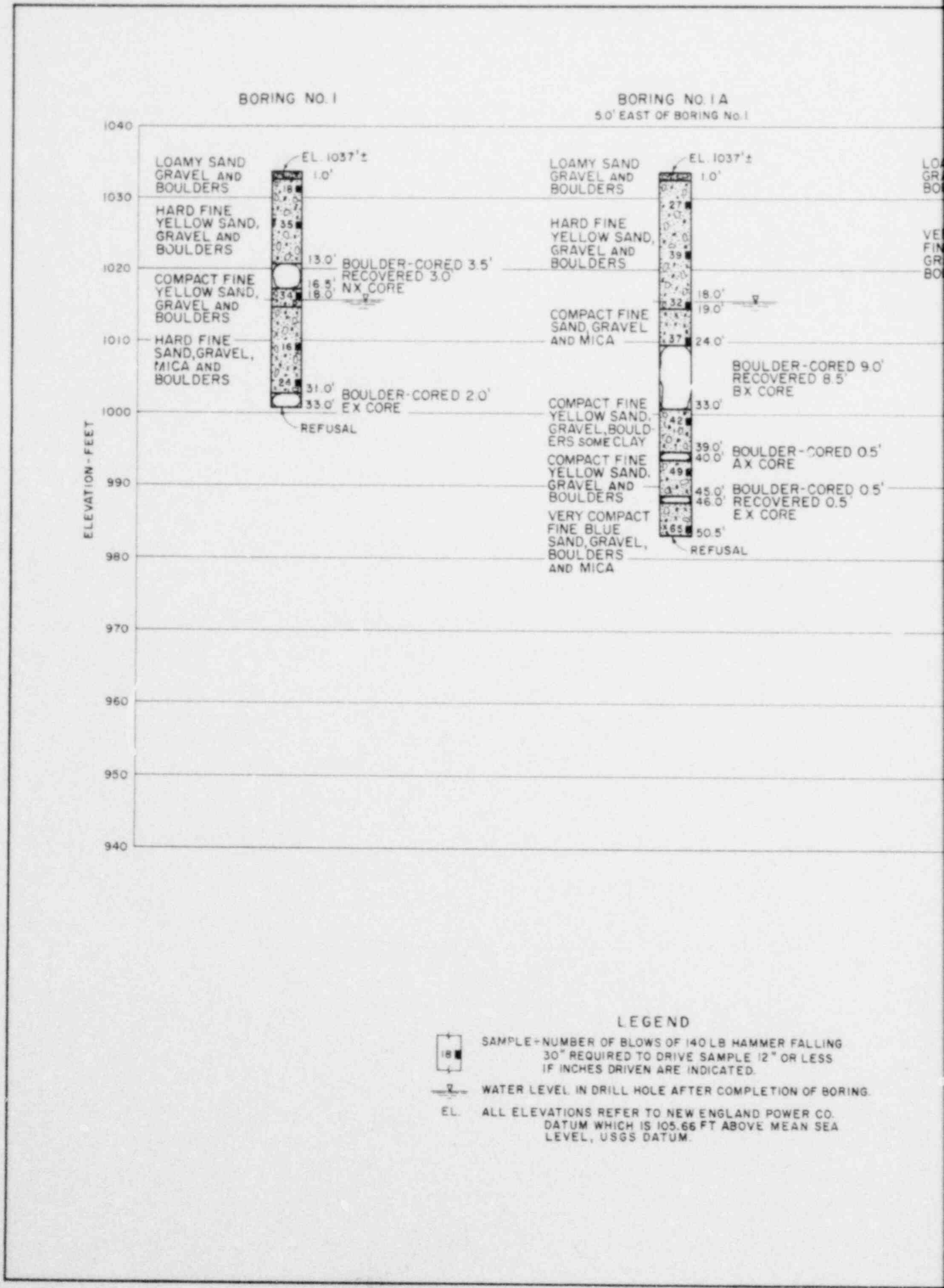
The soils disclosed by the borings as shown on page 303:3 are primarily medium to fine sands with gravel, cobbles, and boulders. These soils are glacial tills, most probably laid down as bed moraine by the ice sheet. They comprise a heterogeneous mass of soil dumped into place by the glacier and compacted by its weight. Some individual boulders are 10 to 12 ft in size. The upper photograph on page 303:4 shows typical soils exposed in the gravel pit. The lower photograph on page 303:4 shows large glacial boulders exposed along the shore of Sherman Pond. The borings indicate that the deeper lying soils are somewhat more compact and contain a slightly greater percentage of clay and silt size particles than the upper soils. The seismic survey also indicates the deeper lying soils to be somewhat more compact, as velocities were higher than in the surface materials. The bedrock is composed of Archean Metamorphics predominantly schists and gneiss. The rock is fresh and free of weathering. Although jointed, this is a strong, stable rock.

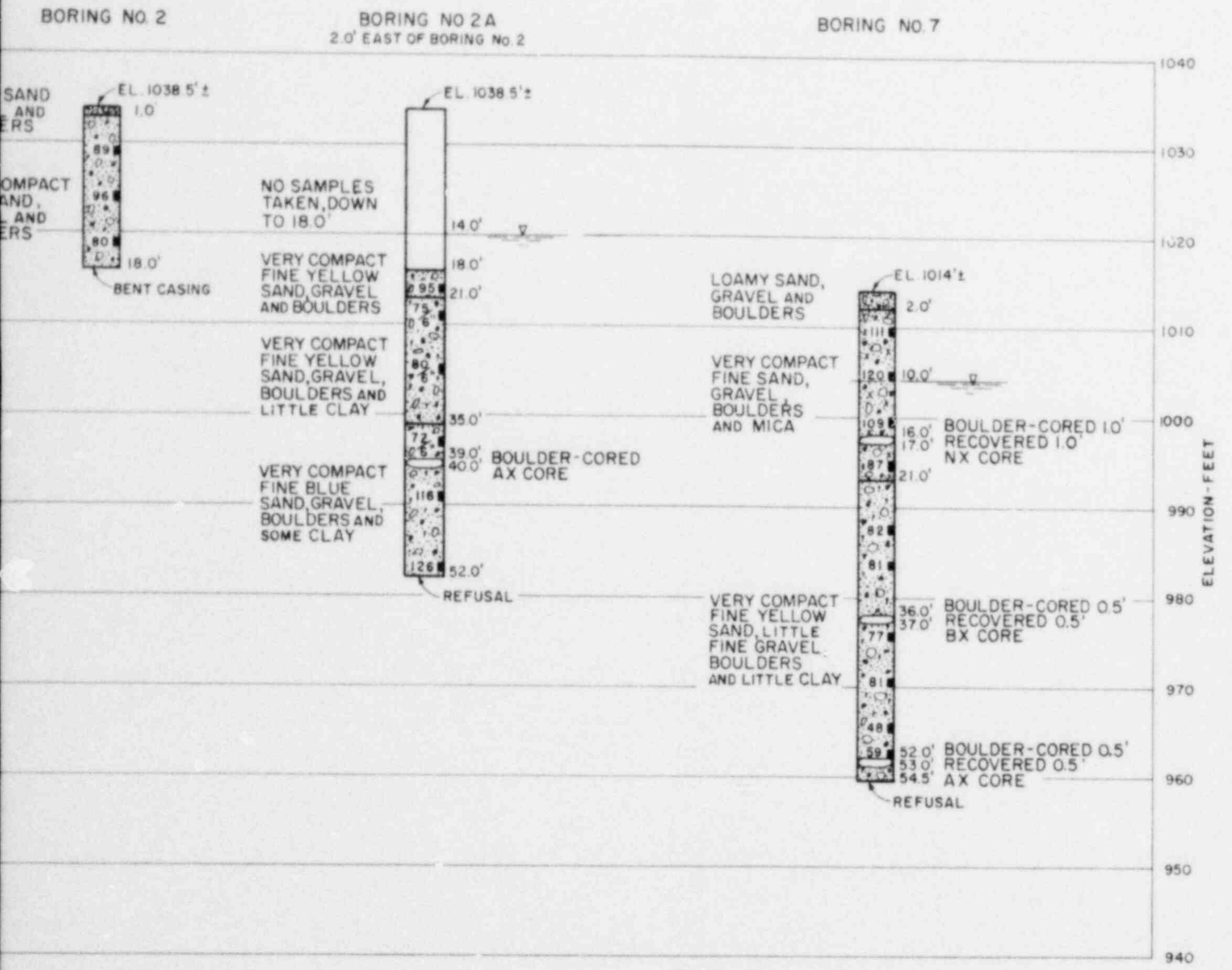

EL. 920'
EL. 865'
EL. 875'
EL. 890'
EL. 1025'
AUXILIARY BAY
VAPOR CONTAINER
PRIM AUXILIARY BUILDING
NO. 2
FUEL TRANSFER PIT
PAD
PAD
ION EXCHANGE PIT
VAULT FUEL STOR.
WASTE DISPOSAL BUILDING
BASE LINE
S4P-48'E. ℄ SHERMAN DAM
0 50 100 150 200
SCALE-FEET
LEGEND
EL. 880'
SEISMIC SURVEY LINE
ELEVATION OF BED ROCK
BORING
A PHOTOGRAPH



NOTES:
ALL ELEVATIONS REFER TO NEW ENGLAND POWER CO. DATUM WHICH IS 105.66 FT. ABOVE MEAN SEA LEVEL, USGS DATUM.

BORING AND SEISMIC SURVEY PLAN


BORING NO. 1
BORING NO. 1 A
5.0' EAST OF BORING No. 1
ELEVATION - FEET
1040
1030
1020
1010
1000
990
980
970
960
950
940
EL. 1037'±
LOAMY SAND GRAVEL AND BOULDERS
1.0'
HARD FINE YELLOW SAND, GRAVEL AND BOULDERS
13.0'
BOULDER-CORED 3.5' RECOVERED 3.0' NX CORE
COMPACT FINE YELLOW SAND, GRAVEL AND BOULDERS
16.5'
18.0'
HARD FINE SAND, GRAVEL, MICA AND BOULDERS
31.0'
33.0'
BOULDER-CORED 2.0' EX CORE
REFUSAL
18
35
34
16
24
EL. 1037'±
LOAMY SAND GRAVEL AND BOULDERS
1.0'
HARD FINE YELLOW SAND, GRAVEL AND BOULDERS
18.0'
19.0'
COMPACT FINE SAND, GRAVEL AND MICA
24.0'
BOULDER-CORED 9.0' RECOVERED 8.5' BX CORE
33.0'
COMPACT FINE YELLOW SAND, GRAVEL, BOULDERS SOME CLAY
39.0'
40.0'
BOULDER-CORED 0.5' AX CORE
COMPACT FINE YELLOW SAND, GRAVEL AND BOULDERS
45.0'
46.0'
BOULDER-CORED 0.5' RECOVERED 0.5' EX CORE
VERY COMPACT FINE BLUE SAND, GRAVEL, BOULDERS AND MICA
50.5'
REFUSAL
27
39
32
37
42
49
65
LEGEND
SAMPLE - NUMBER OF BLOWS OF 140 LB HAMMER FALLING 30" REQUIRED TO DRIVE SAMPLE 12" OR LESS IF INCHES DRIVEN ARE INDICATED.
WATER LEVEL IN DRILL HOLE AFTER COMPLETION OF BORING.
EL. ALL ELEVATIONS REFER TO NEW ENGLAND POWER CO. DATUM WHICH IS 105.66 FT ABOVE MEAN SEA LEVEL, USGS DATUM.



LOG OF BORINGS

TYPICAL SOIL CONDITION

LARGE GLACIAL BOULDER

304 SEISMOLOGY

According to N. H. Heck's "Earthquake History of the United States" (Special Publication No. 149, U.S. Department of Commerce, Coast and Geodetic Survey), only two earthquakes of sufficient intensity to be felt by any considerable number of people have epicentered within 50 miles of the site; one in 1875 near Canon Mountain, Connecticut and one in 1884 in sourthern New Hampshire. Earthquakes epicentered in distant regions may have been felt slightly, one in 1925 epicentered in the St. Lawrence Valley was felt as far south as Virginia, but the damage done by it was limited to the St. Lawrence Valley, in areas of soft, unstable soils. Rev. Daniel Linehan S.J., Director, Weston Observatory, in a memorandum dated April 29, 1955, indicates that this site is in one of the areas of least seismicity in the northeastern United States and that the risk of shock is very slight, but consideration should be given to the possibility of a weak or moderate earthquake. However, damage from earthquakes is greatest where there are soft, unstable soils of considerable depth. At this site, where the soil is firm and rests on bedrock at shallow to moderate depths, earthquakes of moderate intensity will not damage modern framed structures designed to withstand reasonable wind loads.

305 ENVIRONMENTAL RADIOACTIVITY SURVEY

Pre-Operational Survey

The objectives of this program are twofold:

To establish a local normal or base level of radioactivity which will include the natural radioactivity present in all materials, plus fallout from weapon tests and other nuclear discharges wherever they might occur.

To provide a valid basis for identifying significant changes in environmental radioactivity level resulting from operation of the reactor.

To accomplish these objectives, Yankee contracted with Combustion Engineering, Inc., in Windsor, Connecticut to perform analyses on the following samples as part of the pre-operational site survey commencing in October 1958:

Type of Samples

Soil
Vegetation (hay)
Fallout (gummed paper)
Water (river, rain, snow)

These samples are collected by Yankee personnel. The method of collection and shipment of samples to the Combustion Engineering Laboratory is in accordance with procedures prescribed by Combustion Engineering, Inc. Sampling locations were selected jointly by Combustion and Yankee.

The following analysis is made on the above samples:

Soil

A minimum of 12 samples are collected monthly and analyzed for alpha, beta and gamma activity.

At least 3 times per year, soil samples are analyzed for I-131, Sr-90, Cs-137, and uranium on an alpha count basis.

Vegetation

12 samples of hay are collected 3 times per year and analyzed for alpha, beta and gamma activity.

At least 3 of these samples per sampling period are analyzed for Sr-90.

Fallout

Fallout stands utilizing gummed paper are located at 6 of the soil sampling stations. The gummed papers from these locations are collected weekly and analyzed for alpha, beta and gamma activity.

Water Samples

One river water sample is collected monthly and analyzed for alpha, beta, gamma and gamma spectra. Six of these samples per year are analyzed for Co-58, Co-60, and uranium as alpha activity.

One weekly integrated rain water sample is collected and analyzed for alpha, beta, gamma and gamma spectra.

Duplicates of all samples shipped to Combustion Engineering, Inc. are retained by the Yankee field laboratory located at the plant site. These samples are analyzed for gross beta and gamma activity, utilizing the same chemical procedures and similar counting equipment to that used by the Combustion Engineering Laboratory. The results from the Yankee analysis are cross checked against the Combustion results to further ensure the validity of the data. A one pint container of each soil sample is permanently stored at the plant site for historical purposes.

A historical record of all results reported by Combustion is retained at its facility in Windsor, Connecticut. A historical file of all data reported by Combustion and the Yankee field laboratory is maintained at the Boston Office of Yankee.

A program of continuous monitoring of airborne activity began in October 1956. A scintillation type detector with energy discriminator is directly connected to an automatic time printout. By this means, the counting rate integrated over the energy spectrum is obtained as a permanent record. These data are correlated with weather conditions, particularly precipitation and snow cover, by which means many of the variations which occur can be explained.

A Map-1 continuous monitor for air particulate radioactivity using a G-M tube was purchased from Tracer Lab and placed in operation in February 1959. The data from this detector is being correlated with the data from the scintillation detector. Since the Map-1 monitor is of the type generally used throughout the industry for this application, it will eventually replace the scintillation detector as the permanent site air particulate monitor.

Post-Operational Survey

Basically the post-operational monitoring program will be a continuation of the pre-operational program, the major difference being the extent.

All radioactive releases from the plant will be continuously monitored and recorded, once the initial operation of the plant has commenced. Details of the radiation monitoring system are described in Section 215, RADIATION MONITORING SYSTEM. With complete information available on the amount of radioactivity released from the plant, the need for an extensive post-operational survey will be limited.

The unknowns that would change the level established by the pre-operational survey are weapon tests and nuclear discharges from sources other than the Yankee plant.

Therefore, the post-operational survey program consists of the following:

Soil

12 samples collected from the same locations as used in the pre-operational survey, 2 collection periods per year (late spring and early fall). The samples will be analyzed for gross beta and gamma activity.

Water

2 samples will be collected bi-monthly, one upstream and one downstream from the plant. These samples will be counted for gross beta and gamma activity.

Air Particulates

Two continuous monitors, one located approximately four miles above the plant on the site of the Harriman hydroelectric station and the other approximately one-half mile below the plant will be used for determining gross beta and gamma activity of air particulates. The plant is located in a valley approximately one-half mile wide. As a result the prevailing winds either blow up or down the valley. The location of the two monitors is such that the air particulates will be monitored both upwind and downwind of the plant.

The data from the soil, water, and air samples will be checked against the radioactivity levels established by the pre-operational site survey. If a major difference exists, a detailed analysis for specific radio nuclides will be made.

This program will be carried on by the Yankee plant laboratory, except where a detailed analysis for radio nuclides is to be made. This type of analysis will be contracted to an independent laboratory.